FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO

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FEDERAL EXPERIMENT STATION IN PUERTO RICO

Mayaguez, P. R.

Administered by the Office of Experiment Stations, Agricultural Research Administration
United States Department of Agriculture

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[1] In cooperation with the Government of Puerto Rico.

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INTRODUCTION

Fifty Years of Research

On July 2, 1951, the beginning of this fiscal year, the Federal Experiment Station in Puerto Rico celebrated its fiftieth anniversary. An appropriate ceremony was held on the station grounds, with many distinguished visitors from the continent and Puerto Rico. Dr. R. W. Trullinger and Dr. E. C. Elting, Chief and Associate Chief, respectively, of the Office of Experiment Stations, which has been responsible for the administration of the station since its establishment, were present. The Secretary of Agriculture was represented by Mr. Nathan Koenig, who presented a Superior Service Award to the station "for exceptional achievement in research on problems of tropical agriculture." In presenting the award, Mr. Koenig summarized the achievements of the past 50 years of agricultural research at Mayaguez. It is felt that his presentation is worth recording permanently, and that his words on the occasion are of sufficient interest to become part of this fiftieth annual report of the station.

Milestones at Mayaguez, by Nathan Koenig, Assistant to the Secretary of Agriculture

This is a very significant occasion in the life of an institution. Also, this is a noteworthy event in the lives of those men and women who through the years helped mold the shape and character of this same institution. For today, here at Mayaguez, we are celebrating the fiftieth anniversary of the

Federal Experiment Station in Puerto Rico. Here is an institution that has turned the half-century mark with an enviable record and thus has set the standard for even greater achievement in the next half century ahead.

The contributions made by this experiment station to the basic knowledge of mankind have spread throughout the world. What has been accomplished here through research and experimentation helped maintain American leadership in the field of agriculture and contributed to better living for people at home and abroad. In this instance, size has been no yardstick of greatness. For this is a small institution with definitely limited resources. Fortunately, however, there has been an unlimited zeal among the men and women working here. And under the guidance of outstanding leadership many of the deficiencies in physical operating resources have been overcome—but not without some difficulty and hard labor. During most of the last decade the work of this station has been directed by Dr. Kenneth A. Bartlett. He and his coworkers have built well on foundation stones laid by earlier hands.

While it is always a pleasure for me to come to Mayaguez, I am particularly happy to be here at this time. For, in addition to this being the observance of a fiftieth anniversary, it is also the occasion for official recognition of the accomplishments of the Federal Experiment Station in Puerto Rico by the United States Department of Agriculture. It is my privilege and honor on this notable day to be the personal representative of the Secretary of Agriculture, the Honorable Charles F. Brannan, and I bring to you his sincere greetings and best wishes.

So here today we have a double observance—the celebration of a birthday of an institution and the presentation of an award in official recognition of achievement. Such an occasion is truly a milestone in the life of an institution and reflects great credit on the men and women associated with it.

Back in the early years of the century, this experiment station served to establish a sound technical basis for the agriculture of Puerto Rico. In fact, at that time it accomplished what the Point IV Program of providing technical assistance endeavors to do in many parts of the world today.

All of us, I am sure, appreciate the fact that the results of basic research must first be available before much can be done to improve the agriculture and the living standards of people in any area of the world. Such a concept undoubtedly motivated the establishment of the Federal Agricultural Experiment Station in Puerto Rico. This station became the first stone in the foundation of a healthy agriculture in Puerto Rico.

It was shortly after Puerto Rico came under the American flag that the United States Congress authorized use of a small sum—five thousand dollars—to survey agricultural conditions on this Island. The man who made the study was Dr. Seaman A. Knapp, who had been active in the establishment of the State agricultural experiment stations. It was on September 22, 1900, that Dr. Knapp made his report to Secretary of Agriculture James Wilson. President William McKinley transmitted that report to the Congress on December 10, 1900. It was this report that set in motion the chain of events that gave birth to this institution 50 years ago.

In the Department of Agriculture appropriation act for the fiscal year beginning July 1, 1901, Congress authorized the Secretary of Agriculture to spend 12 thousand dollars to establish and maintain an agricultural experiment station in Puerto Rico. This was the real beginning that pumped lifeblood into agricultural research in Puerto Rico. During the first year, experimental work of a temporary nature began at Rio Piedras. The understanding was that after the territorial legislature met again early in 1902, a permanent site would be found for the agricultural experiment station. After the territorial legislature had taken the necessary action, Mayaguez was chosen as the permanent site and actual operations began on this location in September 1902. Each year, in the Department of Agriculture appropriation act, the Congress has made available funds for the operation of this experiment station in support of a sound policy of agricultural development through research. And while the annual expenditures here have increased considerably since the first appropriation was authorized, the returns have far exceeded the outlay.

It is not necessary for me to go into detail on the contributions of this station toward the improvement of agriculture in Puerto Rico. From 1902 to 1934, this station was a prime factor in the agricultural progress of Puerto Rico. Let me mention only a few of the milestones.

As you know, farming in Puerto Rico was in a more or less primitive stage in the early 1900's. Insects, diseases, and inferior varieties seriously handicapped farmers in both crop and animal production. One of the first contributions made by the station was in the identification of serious plant diseases and destructive insects and the development of methods for their treatment and control. Many trees and plants that showed promise for Puerto Rico were introduced, thus contributing much toward utilizing some of the Island's natural advantages and enriching its economy. The station's work on diseases of sugarcane and the development of improved varieties not only eliminated for Puerto Rico's sugar industry the serious threat of destruction which appeared around 1920, but also provided a solid basis for large-scale growth of an enterprise which will long hold the spotlight of importance in the economy of this Island. The first silo in Puerto Rico was built here at Mayaguez in 1908. The first tank for dipping cattle was built which demonstrated what dips can do to prevent spread of cattle diseases. Animal improvement began early with the importation of better cattle, hogs, and poultry. This laid the foundation for the development of a more productive livestock industry on the Island. In fact, there is no single phase of agriculture toward which this station of Mayaguez did not make material contributions. For years, this was the only institution in a position to make an organized attack on the many agricultural problems confronting Puerto Rican farmers.

More recently, however, Puerto Rico has had its own agricultural experiment station just as is found in any of the States. This insular station is located at Río Piedras and serves the interests of Puerto Rico exclusively while the Federal Experiment Station here at Mayaguez serves the broad interests of the United States as a tropical research center. This transition was made possible by the Act of 1931 passed by Congress to place Puerto Rico upon the same status as the individual States as to Federal grants for agricultural research. In this way Congress recognized that Puerto Rican agriculture had come of age and was ready to receive the same privileges and assume the same responsibilities as those enjoyed and exercised by the land-grant institutions of the individual States.

Because of delay by the Legislature of Puerto Rico in giving its required assent to the Act of 1931, it was not until the fiscal year 1934–35 that the insular station received its first Federal payment. This amounted to $25,000. As the Insular station developed and received the annual increases in funds as provided by the Federal law, more and more of the agricultural work of primary concern to Puerto Rico was shifted over from the Federal station at Mayaguez to the Insular station at Río Piedras. Thus, the establishment of the insular agricultural experiment station made possible a shift in policy governing the operation of the station at Mayaguez. The Federal Experiment Station at Mayaguez was charged with broader responsibilities as a Federal tropical outpost of the United States Department of Agriculture. As such, it was to serve as departmental headquarters for all USDA bureaus doing research on the Island. And, also, it was to become the center for the Department's tropical research.

Today the Federal Experiment Station here at Mayaguez is the only tropical research center operated exclusively by the United States Department of Agriculture. And in that capacity it serves the broad interests of the Nation and has done much to speed and greatly advance agricultural research in the United States and the world over. Most of the work that is done here is concerned mainly with the more fundamental aspects of problems relating to continental agriculture and problems of direct concern to national policy and national security. And the various agencies of the Federal Government look to this station at Mayaguez for information, planting material, and scientific and technical advice in carrying out their programs relating to agriculture in various parts of the world.

Let me mention just briefly a few of the high lights that have given the Federal Experiment Station in Puerto Rico recognition as an integral part of the national research program of the United States. During World War II, while oriental sources of quinine were in enemy hands, the chemists at Mayaguez devised a simple and quick method to determine the quinine and total alkaloid content of cinchona bark. The need of our Armed Forces for quinine resulted in a concerted effort to obtain planting stock of cinchona in friendly tropical countries where it might be grown. As a result of research at Mayaguez, cinchona is now being grown commercially in

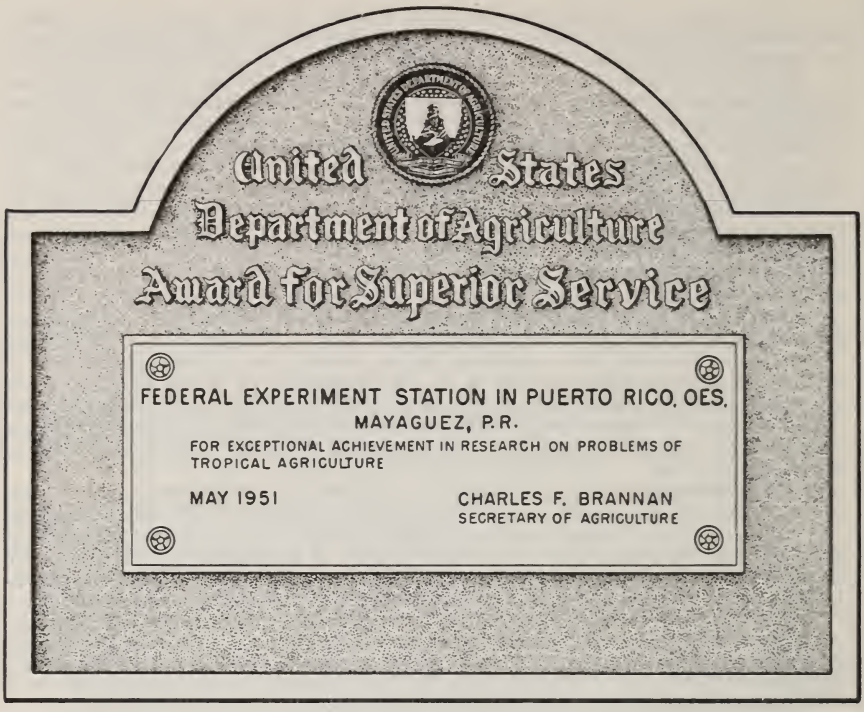

FIGURE 1.—Plaque presented on occasion of Superior Service Unit Award on fiftieth anniversary of the Federal experiment station.

Guatemala, Costa Rica, and other Latin American countries. No longer is the world dependent on a single source of supply for this drug. And again in the present emergency, the Mayaguez station is the scene for fundamental research of a highly confidential nature which can only be done under tropical conditions such as are found here in Puerto Rico.

The policy of carrying out the types of research as are conducted here at Mayaguez is similar to that followed in the continental United States. In general, the research activities of the Department of Agriculture are confined to regional and national agricultural problems while local problems are left to the State agricultural experiment stations. And while the work of this Federal station concerns the problems of broad areas, some of the results of this research are of direct benefit to Puerto Rico. Close working relationships exist between the Federal station and Insular station and both are always ready to cooperate with each other. And over-all, the work of both stations is coordinated through the Chief of the Office of Experiment Stations at the Department of Agriculture in Washington, D. C., as provided by the Act of 1931. The people of the States and the people of Puerto Rico have benefited greatly from this arrangement which affords far greater resources for agricultural research than otherwise would be possible.

Speaking for the United States Department of Agriculture, I can assure you that the Federal Experiment Station here at Mayaguez has achieved a record of accomplishment of which the Department is justly proud. This record of achievement is one in which the people of Puerto Rico may also take great pride if for no other reason than the fact that Puerto Ricans have helped shape that record. Here at Mayaguez you have adhered to the high traditional standards for which American research in agriculture has become known throughout the world. Not only have you applied yourselves with initiative and diligence in your immediate work, but you also have unhesitatingly helped all who sought assistance. As in our research relations with all State experiment stations, you have cooperated freely

with the Insular Agricultural Experiment Station at Río Piedras as well as with other Insular and Federal agencies. Such close working relationships are not only desirable, but they are vital. Only through frequent consultation and the sincerest effort at cooperation can agricultural research march forward and make its maximum contribution to human welfare.

Yes, this is a very significant occasion in the life of an institution. A golden jubilee celebration is a noteworthy event specially with the fine record of achievement that has been built up through the half century of service. Because of this outstanding accomplishment and its unique position in tropical agricultural research, the Federal Experiment Station at Mayaguez has been selected by the United Stated Department of Agriculture as recipient of a 1951 Superior Service Unit Award. The citation reads as follows:

"For exceptional achievement in research on problems of tropical agriculture."

In the full spirit of recognition which these 10 words imply, I assure you it is an honor and a pleasure for me to present, on behalf of the United States Department of Agriculture, this Superior Service Unit Award to the Federal Experiment Station in Puerto Rico. I hope that this beautiful bronze plaque will be as lasting as will be the contributions of this station to the agriculture and the welfare of people everywhere.

In closing this introduction, the last paragraph of a letter received from Secretary Brannan is quoted: "You have my most sincere congratulations on the fine record established by the station during the past half century, and my best wishes for continued success."

The results of research conducted during the past year are briefly summarized in the succeeding pages. More detailed accounts will be found in other station publications and in various scientific journals referred to under "Publications."

PERSONNEL

Two additions to the Federal staff were made during the year. William C. Kennard, instructor of pomology, Department of Horticulture, Pennsylvania State College, was appointed horticulturist on April 24, 1952. L. A. Snyder, assistant professor, Department of Plant Sciences, University of Oklahoma, joined the staff as geneticist on May 29, 1952.

Caleb Pagán Carlo, chemist, returned to the station on August 20, 1951, after a year's leave of absence for graduate work at Oklahoma Agricultural and Mechanical College.

The following changes occurred during the year in personnel employed with funds appropriated by the Government of Puerto Rico: Frank Llavat joined the staff on July 16 as agronomist; Narciso Almeyda began a year's leave of absence to attend graduate school at the University of Florida, on July 11, and was replaced by Francisco Rodriguez Colon on August 1.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The Insular Government appropriated funds amounting to $45,000 for the Federal Experiment Station to carry out cooperative experimental work on agricultural problems of particular interest to Puerto Rico, including investigations on vanilla, spices, weed control, essential oils, and bamboo.

The Experiment Station of the University of Puerto Rico and the Federal Experiment Station continued to maintain close relations. The cooperative tomato, papaya, and forage-improvement projects

were continued. Through conferences of staff members, the two stations maintained a well-coordinated program. The Federal Station provided office, laboratory space, and land facilities for the experimental work with coffee conducted by the Insular Station at Mayaguez. This coffee project was transferred to Castañer, P. R., in February 1952.

The Extension Service of the University of Puerto Rico was extremely helpful in the distribution of plant material to farmers, and in the dissemination of technical information developed by the station.

The Forest Service continued to make land available to the station at Toro Negro, Maricao, and Guanica, for the testing of various tropical plants.

The Puerto Rico Industrial Development Co. cooperated with the station in the distribution of cured bamboo culms for industrial purposes.

A number of projects were carried out in cooperation with other bureaus and agencies of the Department. Office, laboratory space, and other station facilities were provided for Dr. D. M. Eny, biochemist, employed by the Division of Rubber Plant Investigations of the Bureau of Plant Industry, Soils, and Agricultural Engineering, to study basic problems in the production of rubber latex. Also, a cooperative project was initiated with the Rubber Division to study problems of pollination and propagation in *Hevea brasiliensis*. Dr. H. E. Warmke, of the station staff, was sent to the Amazon region of Brazil for a 6-week period to study Hevea pollination under jungle conditions. Investigations on the improvement of sweetpotatoes and the introduction of varieties resistant to fusarium wilt were carried out in cooperation with the Vegetable Crops Division of the same bureau. Experimental trials with various species of *Strophanthus* were started in cooperation with the Division of Plant Introduction and Exploration, BPISAE.

Office space was provided for the cooperative inspector of the Insular Plant Quarantine Service, and for the Soil Conservation Service.

Close relations were maintained with the Office of Foreign Agricultural Relations of the Department in the exchange of technical information and plant material. The cooperative bamboo experiments initiated 3 years ago in collaboration with Dr. F. A. McClure, Field Service Consultant on Bamboo for the Office of Foreign Agricultural Relations, were continued.

Station facilities and personnel were utilized to train Point IV appointees from Pakistan and Perú.

Individuals and various companies have extended cooperation in many ways. Through the cooperation of agencies and individuals scattered throughout the world, many additions have been made to our extensive collection of tropical plants.

PHYSICAL PLANT IMPROVEMENT

The main experiment field area was completely enclosed with a cyclone fence. Damage to experiments from pilfering and other forms of vandalism should be practically eliminated as a result of this improvement. A new pump house and concrete reservoir was installed to facilitate irrigation of experimental plots during the dry season.

A new chemical laboratory was completely outfitted for carrying on work in the field of rubber biochemistry in cooperation with the Division of Rubber Plant Investigations of the Bureau of Plant Industry, Soils, and Agricultural Engineering. One of the older chemical laboratories was remodeled. A new hood and fan were installed and additional bench space was constructed.

INSECTICIDAL-CROP INVESTIGATIONS

DERRIS BREEDING. E. Cabanillas and H. E. Warmke.

Four varieties of trellised *Derris elliptica* (Wall.) Benth., Sarawak Creeping, Changi, St. Croix, and Sumatran, came into flower simultaneously during the spring of 1951 and a large number of intervarietal crosses were made. Fertility was low, with only 4 pods set out of 372 crosses. Low fertility has been noted previously in *Derris* crosses but its cause is not understood. No increase in fertility was observed if crosses were made in the morning or in the afternoon, or if stigmas were pollinated once or on several consecutive days. After the crosses were made some of the blossoms dropped almost immediately; others persisted and even started to form pods, but the majority eventually dropped. Open-pollinated seeds set by plants of the St. Croix variety were observed to germinate readily when pods fell to the earth.

DERRIS SEEDLINGS. C. Pagán.

During the past 2 years trellised plants of the St. Croix and Sarawak Creeping varieties of *Derris elliptica* and of the Sumatran derris growing in the south field seeded profusely. Seeds of all three varieties were successfully germinated for the first time at this station in August 1950; however, most of the plants died during the initial period of growth. In November 1951, the surviving seedlings, which included 13 of the St. Croix variety, 1 Sarawak Creeping, and 3 Sumatran derris, were planted to the field and are growing vigorously.

DERRIS ROOT COMPOSITION. C. Pagán and A. J. Loustalot.

In the last annual report an experiment was described in which the effect of altitude on the growth and insecticidal value of *Derris* and *Lonchocarpus* was studied. The data obtained showed that the percentage of insecticidal constituents in the roots decreased as altitude increased. The roots from this experiment were analyzed for total carbohydrates.

There was a consistent inverse correlation between total $CHCl_3$ extractives and total carbohydrate content expressed either in terms of percentage or in actual weight of constituents per plant.

Low altitudes have warmer temperatures which accelerate the rate of respiration and consequently the utilization of carbohydrates. Higher altitudes with their cooler temperatures reduce respiration. Under these conditions, also, carbohydrates are not consumed as rapidly and therefore accumulate in the root.

ROTENONE SYNTHESIS. C. Pagán.

Three Sarawak Creeping plants grown from seed showed albino characteristics; there was no evidence of chlorophyll and the leaves and stems were creamy white in color. At the age of 2 months the

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roots of one albino and one normal seedling were analyzed separately for rotenoids. The roots of the normal seedling gave a strong positive test which indicated the presence of rotenoids, but only traces of these compounds could be detected in the albino seedling. The slight amount of rotenoids in the roots of the albino plants may be caused by the translocation of these compounds from the seed, which are known to contain rotenoids. Although the number of individuals tested was of necessity small, these results suggest that the formation of rotenone is not a process carried on exclusively in the roots, but rather depends on some compound formed in the leaves and translocated and synthesized in the roots.

MAMEY CHEMISTRY. M. P. Morris.

The resinous exudate of mamey was separated by alkaline extraction into a neutral fraction, 31 percent, and an acidic fraction, 69 percent. The toxic components were found entirely in the acidic fraction, and were recovered upon the neutralization of the aqueous phase. The acid fraction was separated further by precipitation under controlled pH. All acid fractions gave positive phenol tests. When the pH of the strongly alkaline solution of the acidic fraction was carefully lowered the toxic components appeared in the first fractions that were precipitated. It therefore appears probable that the toxic components are weak phenolic acids.

The crude resin was obtained by extracting powdered mamey seed with chloroform for 48 hours. The excessively large number of components in such a mixture makes separation difficult. A promising procedure is to express the highly toxic, aqueous, colloidal solution from the seeds. When this solution is centrifuged all the toxic material is removed along with suspended cellular material. The toxic material can be recovered by ether extraction of the centrifugate as a clear, golden-yellow, viscous oil. This oil contains only 6 components, as compared to the 17 or more found in the chloroform extractives.

The crude extract of mamey produced drastic physiological reactions when taken orally in small quantities. A dosage of 50 mg. per kilogram weight caused dogs to regurgitate the stomach contents. A few milligrams in the mouth of a cat caused a copious flow of salivary fluids. A dosage of 200 mg. per kilogram weight was fatal to guinea pigs in about 8 hours. This fatal dosage of crude extract represents a dosage of approximately 30 mg. per kilogram weight of the toxic principle. Prior to death the test animals maintained their sense of equilibrium and did not experience any convulsive seizures.

Post-mortem examination of the guinea pigs revealed changes in two organs, the stomach and the lungs. The naked-eye appearance of all other organs was normal. A microscopic examination of the blood showed no haemolysis. The mucous membrane of the stomach was badly eroded, especially in the pyloric end. Here the stomach wall resembled wet tissue paper in that it was easily punctured by a mere touch with a dull instrument.

The lungs had a bright-red, flushed appearance. The air vesicles contained watery blood. This condition was probably the cause of death, since the naked-eye appearance of the other organs, except the stomach, was normal.

MAMEY FRACTIONATION. M. P. Morris, C. Pagán, and J. García-Rivera.

A petroleum-ether solution of mamey extract was placed on a column of silicic acid and was developed by washing with ether petroleum-ether mixtures. The extract separated into toxic and nontoxic zones. The more rapidly moving, or lower toxic zone, consisted of four compounds. Two were nontoxic yellow oils, and two were colorless, crystalline, toxic compounds, one melting at 123° C. and one at 129° C. The two toxic crystalline compounds were readily recovered from this mixture after the zone was washed from the column. The second toxic zone consisted of a single yellow band, and yielded a golden-yellow, amorphous solid when the adsorbent was extruded and then extracted with ether. The two crystalline compounds were about one-twentieth as toxic to guppies as rotenone. The yellow amorphous solid was about one-fifth as toxic, i. e., its mean lethal dosage was 0.24 parts per million (p. p. m.), whereas the mean lethal dosage of rotenone was 0.05 p. p. m. under the same conditions. Identification of these three compounds which account for over 90 percent of the toxicity of mamey is now under way.

DERRIS VS. MAMEY TOXICITY. C. Pagán, M. P. Morris, and J. García-Rivera.

The guppy method[1] was used to determine the relative toxicity of mamey to rotenone. Mamey extracts were prepared by soaking the powdered seed in $CHCl_3$ for 48 hours. With this procedure about 5 percent of the dry seed was extracted. A suitable aliquot of the chloroform extract was evaporated and the residue was weighed and dissolved in alcohol. The rotenone standards were also dissolved in alcohol. The toxicity threshold of rotenone was found to be about 0.02 p. p. m. as compared with 1.3 p. p. m. for mamey extract. The median lethal dosage for the latter lies around 1.7 p. p. m., whereas in the case of rotenone only 0.05 p. p. m. was needed to kill 50 percent of the fish population. This indicates that rotenone is about 30 times as toxic as mamey extract to the guppy. The average derris root contains around 10-percent rotenone equivalent; thus, the median lethal dose for guppies when derris root is used is approximately 0.5 mg. of powder per liter of test solution. To obtain the same mortality, 30 to 40 mg. of mamey seed powder are required. The powdered derris root is approximately 60 to 80 times as toxic to the guppy as the powdered mamey seed.

COLLECTION OF ULTRA-VIOLET ABSORPTION DATA OF INSECTICIDAL COMPOUNDS. M. P. Morris, C. Pagán, and J. García-Rivera.

Ultraviolet absorption spectra have now become of great importance in qualitative and quantitative organic chemistry, and have been invaluable in elucidating the geometry of complex molecules. However, these data are of limited value unless properly cataloged. The ultraviolet absorption data of over 200 compounds have been collected and are being converted to a single set of coordinates, a prerequisite of a systematized presentation. Presently, "Log Em vs. Wavelength" is considered the most useful for chemists working in the field of insecticides and is being used in this compilation.

[1] Pagán, C. The use of guppies in the toxicological assay of *Derris* and *Lonchocarpus roots*. Jour. Econ. Ent. 41: 942–945. 1949.

DRUG-CROP INVESTIGATIONS

FIELD STUDIES. H. F. Winters.

It has been the practice in Puerto Rico to transplant seedlings of *Cinchona* to the field during the latter part of the rainy season when heavy rains assure high humidity and high soil moisture. An experiment was conducted to determine whether this practice is sound. The treatments consisted of transplanting seedlings on three different dates—July 25, September 15, and November 15—which represent in general the start, middle, and end of the rainy season. Data obtained after 2 years showed that the record of the late-planted seedlings—57 percent of which survived was outstanding in comparison with survival of early and midseason plantings—24 percent and 25 percent, respectively. The principal cause of death was a root rot disease which is induced by a species of *Phytophthora.*

LIGHT AND NITROGEN REQUIREMENTS. H. F. Winters and A. J. Loustalot.

Experiments were undertaken to determine the light and nitrogen requirements of young seedlings of *Cinchona* prior to transplanting to the field. Plants were maintained in nursery beds under four different light intensities and supplied with nutrient solutions containing three levels of nitrogen. The results obtained indicated that cinchona seedlings can be grown more or less satisfactorily over a rather wide range of nitrogen and light levels, but that the best growth was made when both light and nitrogen were high. The growth as measured by dry weight was significantly better at the three higher light levels than it was at the lowest (one-fourth) light level, particularly when the nitrogen level was also high. Seedlings receiving high nitrogen under full and three-fourths light were more thrifty, had better color, and were generally stronger than those receiving medium or low nitrogen. Apparently cinchona can make good growth without shade if plenty of nitrogen is available. The plants supplied with low and medium nitrogen made significantly less dry weight than those supplied with high nitrogen.

The color of the leaves correlated very closely with their nitrogen content. As the light level decreased, the nitrogen content of the leaves and roots increased, and this was reflected in darker foliage of the plants under low light. The nitrogen content and color of the leaves was also correlated, but to a lesser degree, with the nitrogen treatments applied. The fact that total alkaloids and quinine increased significantly in the roots of the plants as light and nitrogen levels increased indicated that both of these factors are necessary for their formation. Apparently light was the more important factor because no quinine and very little total alkaloid were formed in the roots at the lowest light level regardless of nitrogen treatment. On the other hand, a considerable amount of these constituents was formed in the roots of plants grown under high light even when the level of nitrogen was low.

FOOD-CROP INVESTIGATIONS

STEP TRIALS. E. Cabanillas and H. E. Warmke

Nine introductions in the replicated trials of the Southern Tomato Exchange Program and 29 introductions in the observational trials

were tested for yields at Mayaguez during the year. Two standard varieties, Urbana and Stockesdale, led all others in yield in the replicated trials and STEP 164 and Stockescross No. 1 proved to be outstanding in the observational trials.

PAPAYA BREEDING. H. E. Warmke and E. Cabanillas.

An F_2 population of about 150 plants was grown from an interspecific hybrid made at this station between *Carica goudotiana* (Triana & Planch.) Solms–Laub., and *C. monoica* Desf. These two parental species differ markedly in sex type, in leaf and fruit shape, in fruit and stem color, and in branching habit. The F_2 population segregated widely and has provided an opportunity for a study of the basis of inheritance of these characters. The inheritance of the monoecious versus dioecious sex habit is of special interest.

SWEETPOTATO BREEDING. E. Cabanillas and H. E. Warmke.

One hundred seventy-five sweetpotato seeds were harvested from 1,347 crosses made during the 1951–52 season at Mayaguez. This represents an over-all success of 13 percent. Nineteen of the seeds (representing a 4.1 percent seed set) came from back crosses in which a Jersey parent was crossed to an F_1 hybrid (Jersey × moist flesh); 124 (24.4 percent seed set) were from moist-flesh back crosses in which a moist-flesh variety was crossed to an F_1 hybrid; 26 (7.3 percent seed set) were from F_1 crosses (moist-flesh × Jersey); and 6 (46.6 percent seed set) were from moist-flesh × moist-flesh crosses. In addition, 29 open-pollinated seeds were collected from various Jersey varieties. Yellow Jersey proved to be the best male parent among the Jersey varieties, with a 12.2 percent set of seeds from crosses, followed in order by Maryland Golden with 7.6 percent, Big Stem Jersey with 5.1 percent, and Jersey Orange with 2.6 percent. No seeds were obtained from 55 crosses in which Orange Little Stem was used as pollen parent. Among the moist-flesh types, B–6122 was outstanding both as a female and as a male parent in crosses, with a seed-set percentages of 31.4 and 12.5, respectively. P. I. 153655 proved a good pollen parent with a seed set of 19.8 percent, but poor female parent with no seeds from 61 crosses. B–6241 was the most fertile of the F_1 hybrids, with a 30-percent set as a female parent and a 48-percent set as a male parent.

The application of a DDT spray (1 pound of 50 percent wettable powder in 50 gallons of water) over the leaves and soil at the base of the plants every 2 weeks has been effective to date in controlling attacks of the sweetpotato weevil (*Cyclas formicarius elegantulus* (Sum.).

SWEETPOTATO FLOWERING. E. Cabanillas.

The following new F_1 hybrids from crosses between Jersey and moist-flesh varieties of sweetpotatoes flowered at Mayaguez during the year: B–6231, B–6239, B–6241, B–6248, B–6254, B–6266, and B–6271. Only two hybrids (B–6222 and B–6228 from the 1949 crosses) failed to produce blossoms. In addition, five hybrids (B–6143, B–6162, B–6164, B–6165, and B–6168) which failed to flower last season have come to flower this year.

MANGOSTEEN SEED VIABILITY. F. Rodríguez-Colón and H. F. Winters.

The short life of the seed of the mangosteen (*Garcinia mangostana* L.) is one of the limiting factors in the propagation of this

delicious fruit. Experiments were undertaken to determine the best methods for storage of mangosteen seed.

Seed stored in moist charcoal dust at room temperature gave the highest percentage of germination (82.5) and remained viable for 7 weeks. Moist peat moss was nearly as good. Both treatments successfully prolonged the life of the seed, probably because they provided a medium suitable for germination which proceeded slowly under the conditions. Most of the seed from these two storage treatments, planted after the first week, showed signs of germination at the time of removal from storage. The germination of seed stored in the fruit was partially inhibited.

Sweet Corn Breeding. H. J. Cruzado.

The fourth generation inbred lines of USDA–34 sweet corn were mostly normal although there were some small plants with sterile tassels and pollen sacks which failed to open. Segregants, such as tublar tops, red colored stems, and weak stalks, which were common in earlier generations, were completely absent. Germination and growth of the inbred lines were good.

PLANT INTRODUCTION AND PROPAGATION

Plant Introduction. H. F. Winters, N. Almeyda, and F. Rodríguez-Colón.

Three hundred and thirty-two introductions were received from five foreign countries and from the United States and Territories. Of particular interest were 50 species of *Strophanthus*, 30 species of *Dioscorea*, 11 varieties of sweetpotatoes, and several forage crops—both legumes and grasses. Two plants of *Piper nigrum* L. were received from Trinidad, B. W. I.

The plants of *Strophanthus* and *Dioscorea* were grown by the Bureau of Plant Industry, Soils, and Agricultural Engineering at Glenn Dale, Md., from material collected in Africa, and Central and South America and will become in part the basis for cooperative investigations with the Division of Plant Exploration and Introduction, BPISAE, in relation to a plant source for the drug cortisone.

Distributions. H. F. Winters, N. Almeyda, and F. Rodríguez-Colón.

Due to the increase in building there has been a great local demand for plants. A total of 6,930 ornamental plants and trees, 120 fruit trees, and 49 blocks of Zoysia sod were distributed during the year. A total of 222 packets of seed representing 187 species were sent to 13 foreign countries and to the United States during the year. Cuttings of *Derris elliptica* were sent to Mexico; scion wood of avocado and seed of a number of coffee varieties were sent to Liberia; plants of vetiver and citronella grass were sent to Brazil; and scion wood of mango varieties to Tortola, British Virgin Islands.

A total of 48 requests for tropical kudzu seed, amounting to 108 pounds, were received during the past year from 10 countries. Puerto Rico was first in number of requests, with 37; and 69 pounds of kudzu seed were distributed locally. Other countries to which seed was distributed were Angola, Argentina, the Bahama Islands, Barbados, Honduras, Jamaica, Mexico, New Guinea, and Trinidad.

MONOCOT GRAFTING. T. J. Muzik and C. D. La Rue.

Monocotyledonous plants have not been propagated by grafting because they have no cambium. However, many monocots have other meristematic tissues such as the intercalary meristem, a region just above the node which retains its ability to grow long after the adjacent regions are mature. By appropriate manipulation of this meristem, it was possible to obtain successful grafts of several monocots.

The young shoot is grasped firmly and broken by a quick pull. The young, thin-walled cells in the intercalary region are weaker than the adjacent mature thick-walled cells and they rupture easily when stress is applied. This same stem may be replaced or a stem of the same size from another plant may be inserted. Using this method, successful grafts of several monocotyledonous species were obtained, including bamboo, sugarcane, guinea grass, and Merker grass.

Histological sections showed that in the graft union, a contact layer war formed between the scion and stock. This contact layer was probably formed by the remnants of cells injured in rupturing the stock and scion, or by the oxidation of cell walls which were separated but not broken, and appeared as a thin dark line along the edges of the graft. This layer later disappeared, presumably by digestion, especially in areas below the vascular bundles, with the simultaneous proliferation of parenchyma cells on scion and stock. Differentiation of these cells into short, oblong, thick-walled tracheids reunites the vascular bundles.

About 6 to 8 weeks were necessary to complete the process. In the rejoining of stock and scion, perfect juxtaposition of the vascular bundles was seldom found. The reunion often took place in a curve, rather than in a straight line, which demonstrated clearly the influence of the vascular tissue on the proliferation and the differentiation of parenchyma cells. Differentiation occurred both downward and upward, although mostly in a downward direction. Best results in grafting were obtained with young vigorous material, with an overall success of approximately 3 percent.

HEVEA POLLINATION. H. E. Warmke.

Through the cooperation of the Division of Rubber Plant Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, it was possible to make studies on natural pollination of *Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg., in the Amazon region of Brazil. These studies indicated that small diptera of the genera *Atrichopogon*, *Stilobezzia*, *Dasyhelea*, and *Culicoides* are the chief agents of *Hevea* pollination in Brazil. These small insects (approximately 1 mm. in length) were observed in flight around the inflorescences and also entering and leaving individual flowers. They were found to carry pollen grains on their antennae, thorax, and wings, and to deposit these on the edges of the stigmas as they entered the female flowers. The small size of these insects, their similarity in color to the petals, and the limited periods of their activity probably explain the failure of earlier attempts to identify them as pollinating agents of *Hevea* in Brazil. Thrips were not considered of importance as pollinating agents.

KENAF PATHOLOGY, T. Theis

Kenaf (*Hibiscus cannabinus* L.) plantings at Mayaguez were found to be attacked by a leaf and stem disease that was very prevalent during the rainy season. On the leaves, the lesions began as water-soaked spots which enlarged to a roughly circular area approximately 10 mm. in diameter. The center dried out and assumed a tan color. In some, this portion dropped out, giving a shot-hole effect. The border had a dark red color. A few lesions per leaf did not cause the leaf to drop, but heavy infestations did cause defoliation. The stem lesions were circular, sunken, and approximately 2 mm. in diameter. The new lesions were found near the growing tip. They did not spread much in size, and appeared to be healed over at the older portions. The stem lesion was important from an economic point of view, since the tissue in this area does not ret out properly and the fibers are held together at every lesion. Macroscopic examination revealed no fungal structures nor bacterial exudate.

On four occasions isolations were made from the diseased tissue. A yellow, motile, small, rod-shaped, bacterium was recovered consistently from such isolations. A similar organism was recovered from isolations of stem lesions. From the four isolations, eight cultures were selected for inoculation. Atypical spots appeared on the leaves of the inocculated plants. From these spots similar yellow bacteria were recovered. In the field near the kenaf plots are perennial cottons with heavy infections of angular leaf spot caused by *Xanthosomonas malvacearum* (E. F. Sm.) Dows. This bacterium also is a small, yellow, motile rod. Since kenaf and cotton are closely related, cross inoculations were made. Isolations of the cotton organism from field material and known cultures of cotton were inoculated in kenaf and cotton, and vice versa. The cotton cultures caused typical angular-leaf spot lesions in cotton but none in kenaf. The kenaf cultures caused typical spots on the kenaf and none on the cotton. It appeared quite certain that the yellow bacterium was the causal agent in this disease of kenaf.

BAMBOO

BAMBOO DISTRIBUTION. F. Llavat Cristy.

During the year 36 clump divisions of *Bambusa tulda* Roxb., 24 *B. longispiculata* Gamble ex Brandis, 3 *B. textilis* McClure, and 2 *Gigantochloa apus* (Roem. & Schult.) Kurz ex Munro, in addition to 35 small plants of *B. textilis*, 28 *B. longispiculata*, and 20 *B. tulda* were distributed in cooperation with the Office of Foreign Agricultural Relations.

In cooperation with the Puerto Rico Industrial Development Company 4,710 linear feet of cured culms of *B. tulda*, 3,417 linear feet of *B. textilis*, 890 linear feet of *B. tuldoides* Monro, 270 linear feet of *Dendrocalamus strictus* (Roxb.) Nees, and 350 pounds of *B. tulda* side branches were made available to continental and local bamboo industries.

BAMBOO HARVESTING. F. Llavat Cristy.

In January 1949, an experiment was started to observe and compare eight harvesting treatments on the yield and quality of *Bambusa tulda* planted 25 feet apart on the square on Catalina clay soil. The vari-

ables in this experiment are: (1) Age of plant at which the harvesting of culms is begun, (2) harvesting cycle, and (3) age of culms when cut. The objectives of the experiment were to determine the effect of the different treatments on: (1) The development of the plant, (2) the quality and yield of culm material, and (3) the labor (cost) of harvesting, and also to produce culm material documented as to age for other studies. On the average the 3-year-old culms in all treatments have the largest diameter and length of the culms harvested to date. Since this experiment is designed to run for several years, no further conclusions can be drawn from the present data.

VANILLA

VANILLA PATHOLOGY. T. Theis and F. A. Jiménez.

Two possible methods of controlling vanilla root rot are being tested: (1) The hybridization of the commercial *Vanilla planifolia* Andrews, susceptible to vanilla root rot with the resistant *V. phaeantha* Reich. and (2) the use of chemotherapeutants. Since approximately 8 years must elapse from the time of hybridization before the value of the cross can be determined this method of control does not offer immediate help. A method by which the root rot susceptible progeny could be screened out at an early age from the resistant plants would be of great aid to a breeding program.

It was thought that the agent responsible for resistance might be present in the juice of *Vanilla phaentha* and if so that it would inhibit the growth of the root rot fungus (*Fusarium batatatis* var. *vanillae* Tucker) in culture. Juices extracted from resistant species did not have any antibiotic effect on root rot cultures growing in petri dishes. These results, however, do not exclude the possibility that extracts prepared in a different manner may not prove antibiotic to the root rot fungus.

Chemotherapeutants which have been used with success against such diseases as fusarium wilt of carnations and tomatoes were tested to see if they might have a similar effect on vanilla root rot. The compounds tested were 4-chloro-3, 5-dimethylphenoxyethanol and 2-norcamphane methanol. The solutions were prepared for use at the recommended rates and were poured over the mulch around each plant at the rate of 25 cc. per plant twice a week. They were applied 2 weeks previous to the date of inoculation and were continued twice a week until the experiment was discontinued. The results obtained showed that the chemotherapeutants tried did not harm the plants nor did they protect them from the root-rot fungus.

VANILLA ROOT ROT CONTROL BY FUMIGATION. T. Theis and F. A. Jiménez.

The limiting factor in vanilla production in Puerto Rico is a root rot caused by a Fusarium disease, *Fusarium batatatis* var. *vanillae*. An attempt was made to control this disease with soil fumigants (chloropicrin and formaldehyde) on plants that had reached bearing age. The plants were prepared for fumigation by cutting away all dead tissue from the vine and the support tree. The base of the support tree was painted with paraffin to help prevent injury during fumigation. A total of 150 cc. of chloropicrin was poured into numerous holes that were made in the mulch. The formaldehyde (40 percent) was prepared as a 1–50 solution and 5 gallons were poured over

the mulch in each treatment. After fumigation, the beds were covered with cloth sacks for 1 week and the tree and the vanilla plant were then sprayed with a bordeaux mixture.

When the sacks were removed, cocopeat was placed on top of the mulch and the stem ends of the vanilla vine were buried in it. Seventy-six percent of the treated plants without pods recovered and 42 percent of the plants with pods recovered after treatment. Root hormones applied as a spray and in lanolin paste to fumigated plants failed to increase rooting. The fumigation results have been sufficiently successful to warrant a large-scale study of the value of fumigants as a control for vanilla root rot.

PARASITIC NEMATODES IN VANILLA. T. Theis and F. A. Jiménez.

There is a possibility that vanilla root rot is associated with the presence of nematodes. In other crops affected with fusarium disease, such as cotton, control may be obtained by using soil fumigants to kill the nematodes. The Division of Nematology, Bureau of Plant Industry, Soils, and Agricultural Engineering,[2] cooperated in research on this subject by examining diseased material in a search for nematode parasites of vanilla. The following genera were reported present in the mulch surrounding the roots or within the root tissue: *Cephalobus*, *Diplogaster*, *Prismatolaimus*, *Actinolaimus*, *Enchodelus*, and *Dorylaimus*. Of these, *Enchodelus* is definitely a plant parasite, *Actinolaimus* is possibly predatory, and many forms of *Dorylaimus* are root parasites. The first three genera are saprophytes. Although none of the forms observed were found in large numbers, the presence of parasitic types does not preclude the possibility that vanilla root rot is associated with nematodes. Experiments in the use of nematocidal fumigants as a control measure are now being carried out.

VANILLA POLLEN VIABILITY. T. Theis and F. A. Jiménez.

One of the handicaps of a vanilla-breeding program is the difference in time of flowering of the four important vanilla species. *Vanilla pompona* Schiede, for example, completes its flowering cycle before *V. phaeantha* Reich. begins. A method known to preserve the pollen of orchids was tried in hybridization experiments with the different species of vanilla. The pollen was preserved by removing the pollen mass, free of appendages, from the flower, transferring it to watch glasses, and keeping it in a dessicator for 48 hours at room temperature. It was then placed in small glass vials, stoppered, and kept in a refrigerator at a temperature of approximately 50° F. Test for viability made 2 weeks after storage showed pollen tube growth in all species. The final test of pollen viability is its ability to fertilize a compatible plant successfully. The following crosses were made with preserved pollen 2 to 3 weeks old; *V. pompona* on *V. phaeantha* stigmas; *V. pompona* pollen on *V. planifolia* stigmas; *V. planifolia* pollen on *V. phaeantha* stigmas; and *V. phaeantha* pollen on *V. planifolia* stigmas. Fifty flowers were used for each type of cross. The pollinations examined 1 month later showed a 100-percent set.

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[2] Identifications by Dr. G. Steiner and Mr. A. C. Tarjan of the Division of Nematology of the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Foreign Pollen Influence. T. Theis and F. A. Jiménez.

McClelland [3] showed that when vanilla flowers of a given species were fertilized with pollen from another species, the development of the fruit was affected. In order to obtain additional information on the influence of foreign pollen on the development of the fruit, flowers of *Vanilla pompona*, *V. phaeantha*, and *V. planifolia* were selfed and crossed and measurements were made on the resulting fruit. The data obtained were in general agreement with that obtained by McClelland.

When *Vanilla pompona* was crossed with *V. phaeantha* or *V. planifolia*, the diameter of the stem end and blossom end, and the weight of the fruit were significantly less than that of fruit from self-pollinated *V. pompona*. The average diameter of the fruits from the self-pollinated *V. phaeantha* was significantly smaller at the stem end and blossom end, and the weight considerably less than that of crosses between *V. phaeantha* and *V. pompona*. However, when pollen of *V. planifolia* was used to fertilize *V. phaeantha* flowers there was no significant difference in the diameter of the stem end and the weight of the pod, but the blossom end was significantly thicker than the self-pollinated *V. phaeantha*.

The fruit from self-pollinated *Vanilla planifolia* was significantly smaller in all respects than fruit from crosses in which *V. phaeantha* pollen had been used to fertilize *V. planifolia*. When *V. planifolia* was pollinated with *V. pompona*, the resulting fruit had a significantly larger stem end and a significantly smaller blossom end than the fruits from the selfed plants. There was no significant difference in weight between the cross-pollinated and the self-pollinated fruits. The column of the flower of *V. planifolia* is much shorter than that of *V. phaeantha* or *V. pompona*. Therefore, it is possible that the ovules near the apex are heavily fertilized and that sparse fertilization takes place near the base of the ovary when the *V. phaeantha* or *V. pompona* stigma has been pollinated with *V. planifolia* pollen.

The pollen tubes of *V. planifolia* may not be able to reach, or may reach in only limited numbers, the ovules in the far end of the ovary. Likewise, the pollen tubes of *V. phaeantha* or *V. pompona*, which normally grow farther than those of *V. planifolia*, may cause a heavier fertilization in the base of the pod than would the *V. planifolia* pollen.

WEED CONTROL INVESTIGATIONS

Physiological and Morphological Studies. A. J. Loustalot and T. J. Muzik.

Studies on the effect of 2,4–D on the photosynthetic activity of velvet-bean leaves showed that even at the lowest strength tested (0.001 percent) the rate of CO_2 assimilation was reduced, and this was associated with vascular tissue modifications particularly in the pholem; xylem formation and presumably water conduction were inhibited. There was very little damage to the leaf of plants treated with 0.01 percent 2,4–D. However, extensive cell proliferation took place in the tissue of the stem and eventual differentiation of root primordia.

[3] McClelland, T. B. Influence of foreign pollen on the development of vanilla fruits. Jour. Agr. Res. 16 (7) : 245–251. 1919.

A gradual decline in the rate of photosynthesis was associated with this condition, but several days elapsed before CO_2 assimilation ceased and the plants died.

Plants sprayed with 0.001 percent 2,4–D showed the same histological effects as those treated with 0.01 percent, but the changes were much slower and less extensive. Growth ceased temporarily but the plants were not killed and photosynthesis continued at a reduced rate for several weeks after treatment. Histological examination of plants treated with a relatively high concentration of 2,4–D (0.01 percent and 0.05 percent) showed that mesophyll leaf tissue was extensively damaged or destroyed within 3 hours after application. This condition coincided with a sharp reduction or cessation of photosynthesis. Plants treated with this concentration died before any pronounced modifications occurred in the tissues of the stem.

Nutgrass Control With CMU. A. J. Loustalot and H. J. Cruzado.

The new herbicide, 3-para-chlorophenyl-1-1-dimethylurea (CMU) was tested in an experiment to control nutgrass, *Cyperus routundus* L. Tuber counts 6 months after treatment showed a reduction of 80 to 90 percent in the number of live tubers in plots that were plowed and treated with 80-pound CMU per acre. This experiment indicated that CMU at relatively high rates reduced the infestation of nutgrass but did not eradicate it. Alternate plowing and split applications of CMU may be more effective. An experiment to test this treatment is in progress.

Movement of CMU in Soil. A. J. Loustalot and H. J. Cruzado.

Studies on the movement of CMU in the soil showed that the material did not move appreciably beyond the first inch of soil regardless of the amount of rainfall applied. These data are in close agreement with those obtained with sodium and diethanolamine salts of 2,4–D and in direct contrast to the results obtained on the same soil type with sodium trichloroacetate (TCA).

Phosphorous Metabolism. A. J. Loustalot.

The percentage of water-soluble phosphorus in leaves of plants of malanguilla (*Caladium* spp.) treated with 2,4–D was consistently higher than in leaves of untreated plants or of plants untreated but uprooted. The phosphorus content of the malanguilla leaves sampled 24 hours and 1 week after treatment was essentially the same, indicating that the 2,4–D had produced its toxic effect rather soon after treatment. Similar results were obtained with *Commelina* sp. A well-replicated and comprehensive experiment to investigate the effect of 2,4–D on phosphorus metabolism is now in progress.

2,4-D on Grasses. A. J. Loustalot.

Experiments showed that mature grass plants can be killed when they are immersed in a solution of 2,4–D for 1 minute or sprayed with a combination of 2,4–D and a latex material. These experiments indicate that differences in susceptibility between grasses and nongrasses are due to mechanical factors rather than to physiological ones.

NUTGRASS PHYSIOLOGY. T. J. Muzik and H. J. Cruzado.

Studies of the effect of 2,4–D on nutgrass showed that a greater number of tubers may be killed by breaking up the chains to induce maximum sprouting before spraying with 2,4–D. 2,4–D is not readily translocated in the underground tuber-system, but is very efficient in killing the sprouts and basal bulbs. Sprouting of the lower tubers may be controlled by auxin produced by the top tuber and could be overcome by injuring the rhizome or separating the tubers. It was shown that nutgrass grows only from preformed buds.

Nutgrass owes its ability to persist in soil partially to the high content of starch grains in the parenchyma cells of the tuber and rhizome, of which it can live for at least a year without sprouting. Treatment with numerous hormones failed to change the pattern of wound healing or to induce adventitious bud formation.

FIELD TESTING OF HERBICIDES. T. J. Muzik, G. W. Luvisi,[4] and H. J. Cruzado.

Twenty-seven new herbicides and combinations were tested on areas of mixed weed infestations. The action of TCA on grasses was improved by combining it with a number of contact herbicides such as aromatic oil, di-nitro-sec-butyl phenol, or diisopropyl dixanthogen. The combination of TCA with pentachlorophenol was not as effective. Although most contact herbicides are soluble only in oil, a new contact herbicide, WES 101, is soluble in both water and oil. However, when tested it was found to be more effective when dissolved in oil. RJL 19, a new systemic herbicide, was the most effective new compound tested on grasses although it did not kill nutgrass.

BREEDING AND EVALUATION OF FORAGE CROPS

GRASS CYTOLOGY. H. E. Warmke and Elida Vivas.

Cytological investigations of the mechanism of reproduction in guinea grass, *Panicum maximum* Jacq., indicated that apomixis—the production of seeds without the union of pollen and egg nuclei—is of common occurrence and probably the predominant mode of reproduction in this species. The same process was found to occur in the related varieties, gramalote, fine-leaf, Borinquen, and broadleaf. Reproduction on the female side is normal until after the meiotic divisions are completed. At this time, however, in a majority of the cases, all four of the reducted macrospores degenerate, and one or more adjacent somatic cells of the nucellus are transformed by growth and division into aposporic embryo sacs. Pollination is necessary for the development of seeds. One of the male nuclei unites with the primary endosperm nucleus and thus initiates endosperm division. After the endosperm has undergone several divisions, the unreduced and unfertilized egg begins to divide.

LEGUME EVALUATION. H. E. Warmke and R. H. Freyre.

Combinations of five legume species with Merker grass (*Pennisetum purpureum* Schum. var. *Merkerii*), in addition to Merker grass and tropical kudzu alone, were grown in a replicated field experiment at Mayaguez. Three of the legumes, cowpea (*Vigna sinensis* (Torner)

[4] In cooperation with the National Aluminate Corporation, 6216 West 66th Place, Chicago, Ill.

Savi), velvetbean (*Stizolobium deeringianum* Bort.), and red bean (*Canavalia bonarensis* Lindley), could not be established or maintained successfully in association with Merker grass. Two other species, tropical kudgu (*Pueraria phaseoloides* (Roxb.) Benth.) and trailing indigo (*Indigofera endecaphylla* Jacq.), grew successfully in association with Merker grass through repeated cuttings over a period of 3 years.

The compatible combinations significantly outyielded either grass or legume grown separately in total forage and in total protein. They also yielded more of the four minerals, calcium, magnesium, phosphorus, and potassium. The increased yields of the compatible combinations were not considered to result from a beneficial effect on either component as a consequence of the association, but rather because the yield of the combined species represents the sum of the yields of inidividual components grown separately. This was atttributed to the fact that in combination the species made a more efficient use of available soil, sunlight, and moisture.

Tropical Kudzu Breeding. H. E. Warmke.

Studies of inheritance of the "hairless" character in tropical kudzu by means of F_2 and backcross segregations indicated that: (1) This character is a mutant of the normal type and has appressed rather that erect hairs, (2) it breeds true for hairlessness when self-pollinated, (3) it probably differs from the normal by a single gene pair, and (4) dominance is absent.

Legume Palatability. H. E. Warmke and R. H. Freyre.

Tests of relative palatability were made on a group of 11 tropical legume species, using the pasture cafeteria method and dairy cattle as test animals. Observations were made during three separate rounds of grazing. The species used were: *Indigoferra endecaphylla* Jacq., *I subulata* V., *Pueraria phaseoloides* (Roxb.) Benth. (hairy and hairless forms), *Stizolobium deeringianum* Bort., *Canavalia bonarensis* Lindley, *Calopogonium coeruleum* Benth., *Desmodium intortum* (Mill.) Urb., *D. nicaraguense* Oerst., *Dolichos lablab* L., and *Centrosema pubescens* Benth.

Trailing indigo (*Indigofera endecaphylla*) was clearly the outstanding single species in the tests. It ranked first in production, second in percent consumption, first in observed grazing time, and first (with velvetbean) in preference. It was not damaged by trampling and heavy grazing, and it recovered rapidly. Although they constituted only 10 percent of the total pasture area, the trailing indigo plots provided 39 percent of the total hours of grazing. The widespread use of *I. endecaphylla* for forage cannot be recommended, however, until the nature and importance of its reported toxicity to farm animals are better understoood.

Indigofera subulata was very similar in appearance and habit of growth to *I. endecaphylla*. It approached *I. endecaphylla* in production and in grazing time, but was somewhat lower in percent consumption and considerably lower in preference. *I. subulata* tolerated heavy grazing and recovered rapidly during rest periods. It was the only other species, besides *I. endecaphylla*, on which the animals spent more than 10 percent of their total time grazing.

Velvetbean, *Stizolobium deeringianum*, ranked with trailing indigo

in preference. This species grows vigorously, makes a rapid ground cover, and smothers out weed competition perhaps better than any other species used in these trials. The fact that it is a short-lived annual and that it suffers markedly from trampling during periods of grazing, however, severely limits its usefulness as a forage species.

Tropical kudzu, *Pueraria phaseoloides*, was average or slightly above average in yield, in percent consumption, in grazing time, and in preference. Cattle ate the flowers and young leaves and stems readily, but did not relish the older plant portions. Kudzu suffered considerably from trampling damage but recovered well during periods of rest. In association with grasses, tests have shown it to be a valuable forage for meat and milk production; it is probably the most generally useful and widely planted forage legume in Puerto Rico today.

Centrosema pubescens was eaten readily by the cattle, but under conditions at Mayaguez it grew so slowly and produced so poorly that it would not seem to hold great promise as a forage legume.

Dolichos lablab had a relatively high preference rating, but its failure to recover after grazing handicaps it seriously as a forage species.

Desmodium intortum was near the top in percent consumption and above average in preference. It is suggested that this species be given more extensive trials in the highlands of Puerto Rico, where it can adapt itself better to conditions than it can on the coastal plain at Mayaguez.

Canavalia bonarensis started rapidly from seed and yielded well during the first grazing round. It was low in percent consumption and also below average in preference. Its value as a forage plant would seem to be limited to situations under which a large volume of coarse vegetation is needed for relatively short periods.

Calopogonium coeruleum and *Desmodium nicaraguense* were lowest in palatability of the entire group. They were lowest in percent consumption and were last to be consumed. These two species would seem to hold little promise as forage crops for dairy cattle in Puerto Rico.

LEGUME TOXICITY. R. H. Freyre and H. E. Warmke.

Feeding trials, in which guinea pigs were used as test animals, were made with *Indigofera endecaphylla* (trailing indigo), and *I. subulata* to detect possible toxicity in these species. The forage was fed green (ground and unground) in combination with a commercial concentrate feed. Tropical kudzu was used in place of the indigofera species as a control ration. All tests were run for a period of 290 days. The animals on the trailing indigo diet consumed an average of slightly less than 21 grams; those on *I. subulata* a little over 24 grams; and those on tropical kudzu slightly over 26 grams of fresh forage per animal per day. Four of the original animals on the trailing indigo diet were alive and healthy at the end of the tests, three of those on *I. subulata*, and seven of those on the control ration. Most deaths occurred because animals failed to eat the diets containing the indigofera forage. On the trailing indigo rations no live young were born during the tests, and seven separate cases of abortion of young at various stages of development were observed. Nine normal parturitions and four cases of abortion were observed among the animals fed on *I. sub-*

ulata. Among the control animals, 13 normal parturitions were observed and only one abortion occurred.

If the *Indigofera* species contains toxic constituents, apparently they are not violently toxic; otherwise animals could not be maintained on diets containing these forages for such long periods of time. The complete failure of reproduction in animals kept on the trailing indigo diet and the poor reproductive efficiency of those on the subulata diet, however, indicate that these diets produce serious physiological disturbances and suggest that it would be wise not to use these species for forage until more complete studies are made.

LEGUME ANALYSIS. M. P. Morris and C. Pagán.

Eleven legumes, *Indigofera endecaphylla*, *I. subulata*, *Pueraria phaseoloides* (hairy and hairless varieties), *Canavalia bonarensis*, *Calopogonium coeruleum*, *Desmodium intortum*, *D. nicaraguense*, *Dolichos lablab*, *Centrosema pubescens*, and *Stizolobium deeringianum* were analyzed for hydrocyanic acid. All species contained only a trace (less than 3 parts per million) except *Indigofera endecaphylla*, which was found to contain 28 p. p. m. by the Winkler method and 7 p. p. m. by the autolyzing method. None of the species was considered to have toxic levels of hydrocyanic acid.

BIOASSAY OF TOXIC COMPONENTS OF TRAILING INDIGO. C. Pagán and M. P. Morris.

An investigation of the chemical nature of the toxic components of trailing indigo was undertaken. Bioassay trials were made with the chick test [5] and with guppies. Both species reacted to the toxic components of trailing indigo. The chicks developed recognizable symptoms within 1 to 4 days when placed on a ration containing the toxic material but completely recovered when placed on a normal ration. This sensitivity permitted relatively easy identification of the fractions containing toxic material throughout the various stages of separation.

The data obtained from preliminary tests showed that complete extraction of the substance responsible for the detrimental effect was not possible with any of the solvents or methods used. Trailing indigo markedly reduced the ability of the chicks to utilize the nutrients in the feed. The results obtained in these preliminary trials with trailing indigo show that: (1) The legume contains a component that is toxic to guppies and chicks; (2) the toxic symptoms in checks are dizziness and convulsions, and a failure to gain weight in proportion to the food consumed; (3) the checks are able to recover after removal from the toxic feed.

WEATHER

The rainfall for the last 6 months of 1951 was 55.14 inches, or 5.11 inches above the 53-year average of 50.03. For the first 6 months of 1952 a precipitation of 27.14 inches was recorded, which was 2.24 inches below the 54-year average of 29.38 inches. The total rainfall for the fiscal year 1951–52 was 82.28 inches, or 2.87 inches above the 53-year average of 79.41 inches.

[5] Rosenberg, M. M., and Zoebisch, D. C. A chick test for toxicity in forage legumes. Agron. Jour. 44: 315–318. 1952.

The mean temperature recorded at Mayaguez, P. R., for the fiscal year 1951–52 was 78.2° F., which was 0.9° F. above the 53-year average of 77.3° F.

TABLE 1.—*Weather conditions at the Federal Experiment Station, Mayaguez, P. R., during the fiscal year 1951–52*

Month	Precipitation [1]			Temperature [2]				
	Total	Greatest in 24 hours	Days with 0.01 inch or more	Mean maximum	Mean minimum	Mean	Maximum	Minimum
1951	*Inches*	*Inches*	*Number*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*
July	14. 06	2. 61	21	89. 7	69. 5	79. 6	91	68
August	8. 04	1. 69	17	90. 5	69. 6	80. 1	94	67
September	14. 04	2. 29	22	90. 8	69. 4	80. 1	94	68
October	5. 91	1. 45	14	89. 8	69. 2	79. 5	94	67
November	8. 53	1. 48	18	88. 4	67. 9	78. 2	92	66
December	4. 56	1. 27	10	85. 7	65. 6	75. 7	90	62
1952								
January	2. 48	1. 98	5	83. 8	68. 4	76. 1	91	61
February	. 34	. 09	8	86. 2	64. 0	75. 1	91	62
March	1. 68	. 54	11	87. 9	64. 6	76. 3	92	61
April	4. 97	1. 37	11	89. 6	67. 3	78. 5	94	63
May	9. 79	2. 51	17	90. 4	69. 5	80. 0	94	67
June	7. 88	1. 54	15	91. 1	69. 9	80. 5	94	68

[1] 53-year average: July, 10.51 inches; August, 10.94 inches; September, 10.85 inches; October, 9.20 inches; November, 5.91 inches; December, 2.62 inches.
54-year average: January, 2.00 inches; February, 1.97 inches; March, 3.58 inches; April, 4.93 inches; May, 8.19 inches; June, 8.71 inches.

[2] 52-year average—Mean temperature: July, 79.1°; August, 79.4°; September, 79.5°; October, 79.1°; November, 77.6°; December, 76.0°.
53-year average—Mean temperature: January, 74.6°; February, 74.7°; March, 74.9°; April, 76.2°; May, 77.9°; June, 78.8°.

PUBLICATIONS ISSUED

In addition to the annual report of the Federal station for the fiscal year 1951, the following publication of the Department was issued during the year:

LOUSTALOT, A. J. List of publications of the Federal Experiment Station in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta., 53 pp. 1951. [Processed.]

The following articles were published by the station staff in periodicals outside the Department:

BARTLETT, K. A. The Golden Jubilee of the Federal Experiment Station in Puerto Rico. Sugar Jour. 14 (3): 48–49, 74, illus. 1951.

BARTLETT, K. A. The Golden Jubilee of the Federal Experiment Station, Puerto Rico. Monthly Information Bulletin (Caribbean Commission) 5 (4): 109–110, 112. 1951.

FERRER, R. The effect of bamboo on succeeding crops. Trop. Agr. [Trinidad] 28: 50–52, illus. 1951.

HAGEMAN, R. H., PAGAN, C., and LOUSTALOT, A. J. The effect of elevation on growth, carbohydrates, and insecticidal constituents of *Derris* and *Lonchocarpus*. Abstract in Amer. Soc. Hort. Sci. Proc. 59: 336. 1952.

LA RUE, C. D., and MUZIK, T. J. Does the mangrove really plant its seedlings? Science 114 (2973): 661–662. 1951.

LOUSTALOT, A. J. 2,4–D Can Kill Mature Grasses. Agron. Jour. 44: 276–277. 1952. (Abstract in Amer. Soc. Hort. Sci. Proc. 59: 483, 1952, and in South. Weed Conf. Proc. 5: 178. 1952).

MUZIK, T. J., and CRUZADO, H. J. Structure and function in nutgrass, *Cyperus rotundus* L. South. Weed Conf. Proc. 5: 24. 1952.
MUZIK, T. J., LUVISI, G. W., and CRUZADO, H. J. A method for statistical evaluation of new herbicides. Agron. Jour. 44: 91–92, illus. 1952.
WINTERS, H. F. Notes on the performance of *Pogonopus speciosus* in Puerto Rico. Florida State Hort. Sci. Proc. 64: 238–239. 1951.
WINTERS, H. F. Fumigation of cinchona nursery soils. Turrialba 1: 296–298, illus. 1951.
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